

# BAIR DAM

## MANUAL FOR OPERATION AND MAINTENANCE

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## OVERVIEW

Bair Reservoir is located in Meagher County approximately three-quarters of a mile northwest of the town of Checkerboard. (Figure 1) The dam and reservoir are located on and fed by the North Fork Musselshell River. They are also fed by canal from Checkerboard Creek. (Figure 2)

The dam is owned by the Montana Department of Natural Resources and Conservation (DNRC) and is managed by the State Water Projects Bureau (SWPB) of the DNRC. The Upper Musselshell Water Users Association (herein called "association") operates the dam.

The earthfill dam was completed in 1939. Bair Dam is 102 feet high and 580 feet long. The dam's outlet works consist of: a concrete intake structure; a 54-inch reinforced concrete arch conduit; a 48-inch diameter butterfly (operating gate) valve; a 48-inch diameter slide (emergency gate) gate; a control tower; and an outlet structure. The control tower contains the gate operators for the outlet gates. The maximum capacity of the outlet works is 650 cubic feet per second (cfs). The spillway located in the left abutment, is an uncontrolled, rectangular, concrete chute. The spillway has an ogee-shaped crest section at elevation 5,325. The crest is 60 feet wide and tapers to a 20 foot wide chute. The maximum capacity of the spillway is 7,880 cfs.

Water from the reservoir is primarily used for irrigation water supply and the reservoir also is used for water-based recreation.

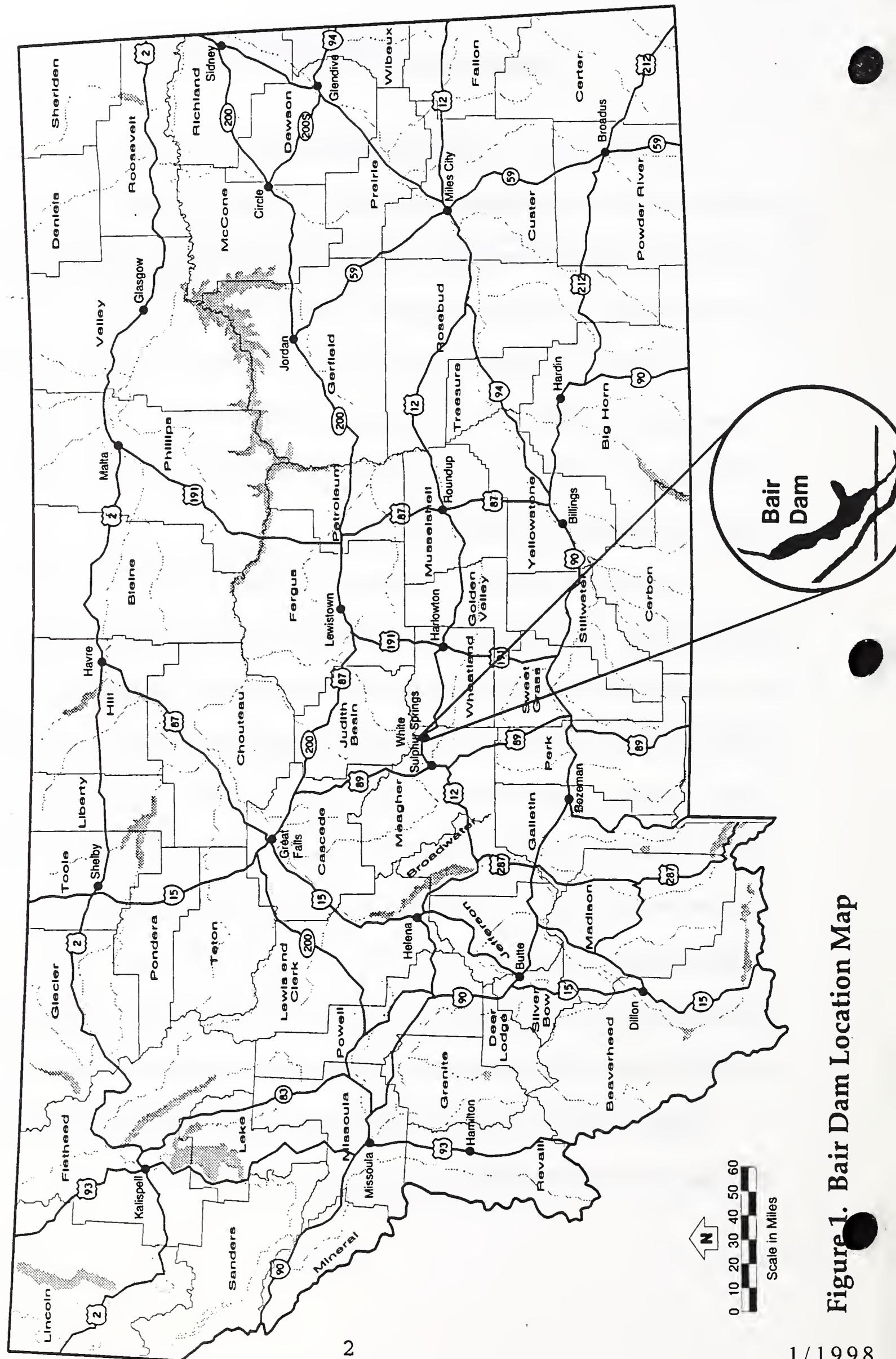


Figure 1. Bair Dam Location Map

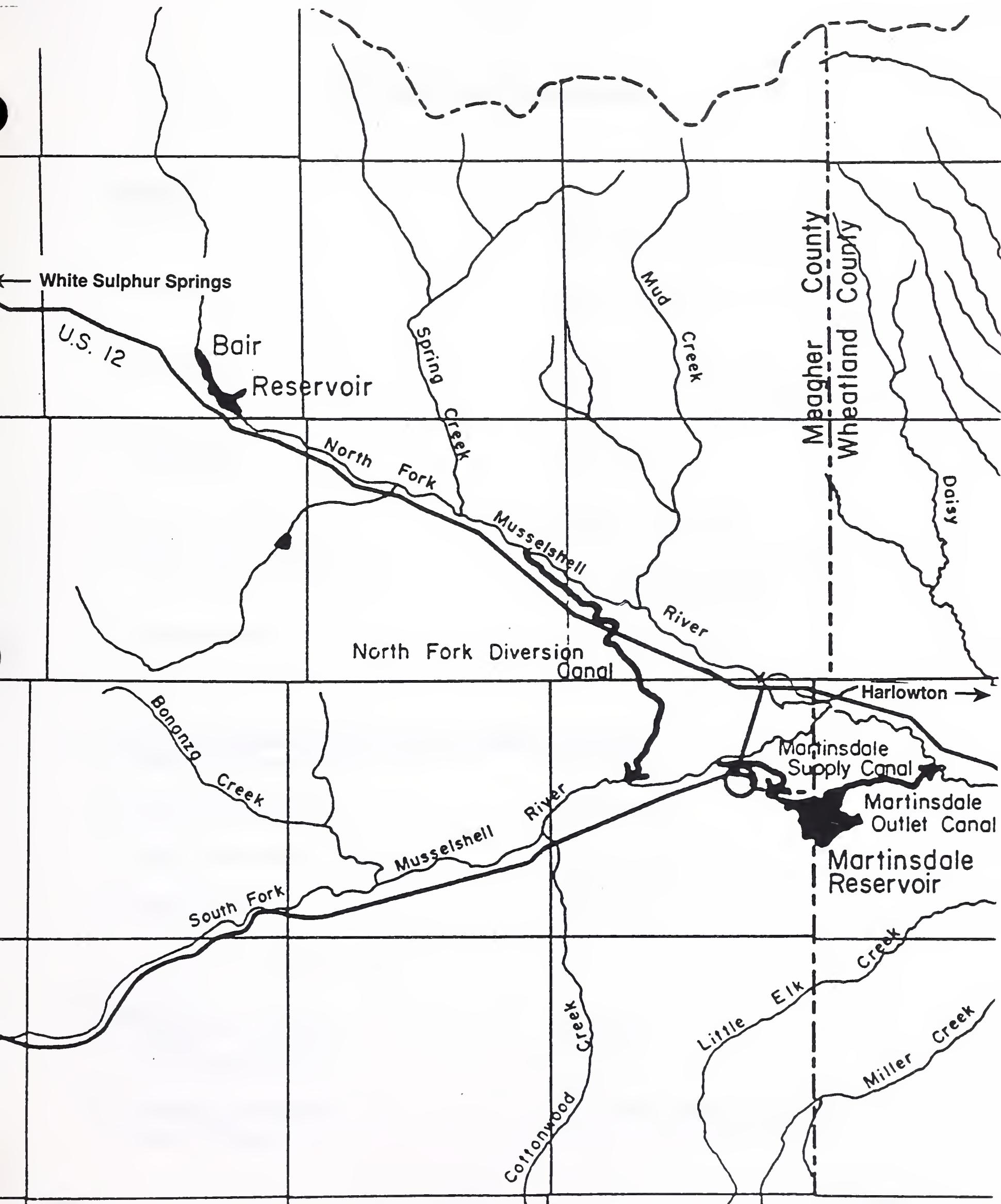


Figure 2. Bair Dam Project Area Map



## **STATISTICAL INFORMATION**

### **1. General**

a) Owner	Montana Department of Natural Resources and Conservation
b) Operator	Upper Musselshell Water Users Association
c) Location	Sections 27, 34 & 35, Township 10 North, Range 9 East
d) Latitude Longitude	46° 34' 48" 110° 33' 24"
e) County--State	Meagher--Montana
f) Watershed Location	North Fork Musselshell River, Missouri River basin
g) Drainage Area	51.1 square miles

### **2. Principal Elevations (feet above mean sea level)**

a) Maximum Dam Crest	5,338.3 feet
b) Settled Dam Crest	5,336.4 feet
c) Normal Full Pool	5,325.0 feet
d) Spillway Crest	5,325.0 feet

### **3. Reservoir**

a) Length of Maximum Pool (approximate)	1.9 miles
b) Maximum Reservoir Level of Record	5,325.5 feet (May 16, 1979)

c) Surface Area at Normal Pool	272 acres
<b>4. Storage</b>	
a) Maximum Storage (elevation 5,336.4 feet)	10,650 acre-feet
b) Active Storage (elevation 5,325.0 feet)	7,005 acre-feet
c) Maximum Surcharge	3,645 acre-feet
<b>5. Hydrology</b>	
a) Inflow Design Flood	0.75 Probable Maximum Flood (0.75PMF; 35,237 cfs peak flow)
b) 100-Year Flood	1,140 cfs
c) 500-Year Flood	1,722 cfs
<b>6. Embankment (Dam)</b>	
a) Type	Zoned Earthfill and Rockfill
b) Hydraulic Height	102 feet
c) Crest Length	580 feet
d) Crest Width	27 feet
e) Downstream Slope (Above Elevation 5,270 feet)	1v on 3.0h
f) Downstream Slope (From Elevation 5,250 to 5,270 feet)	1v on 5.0h
g) Downstream Slope (Below Elevation 5,250 feet)	1v on 1.0h

h) Upstream Slope (Above Elevation 5,325 feet)	1v on 2.0h
i) Upstream Slope (Below Elevation 5,325 feet)	1v on 3.0h

## 7. Spillway

a) Location	Left abutment
b) Type	Uncontrolled Ogee
c) Width	60 Feet Tapering to 20 Feet
d) Length	345 Feet
e) Crest Elevation	5,325 feet
f) Maximum Capacity (At elevation 5,336.4 Feet)	7,880 cfs

## 8. Outlet Works

a) Size	54-inch reinforced concrete arch pipe
b) Length	530 feet
c) Control	48-inch diameter butterfly valve (operating gate) and a 48-inch diameter slidegate (emergency gate) with manual operators
d) Capacity at 5,336.4 feet Dam Crest Elevation	650 cfs
e) Design Invert Elevation	5,236.5 feet
f) Trashrack	Yes



## **OPERATING PROCEDURES**

The association operates Bair Reservoir to provide an adequate supply of irrigation water to meet contracts with water users without exceeding safe storage or flow levels.

### **Method and Schedule of Operation**

The association's goal is to have the reservoir full before contract holders start putting in calls for water. The date irrigation releases begin varies from year to year, with early-May typically the earliest. Irrigation releases usually end by October 1. The actual irrigation season depends on each year's climatological and hydrological conditions.

**Reservoir Level Restriction. Because of the poor condition of the spillway at Bair Dam, a reservoir level restriction was implemented in the spring of 1997. This restriction is permanent until the spillway can be repaired. The maximum water surface in the reservoir is to be no more than elevation 5,322.0 feet, which is 3 feet below the spillway crest elevation of 5,325 feet. The storage at this restricted elevation is 6,244 acre-feet or 761 acre-feet less storage than full pool storage. The restricted storage allows for the routing of the 100-year flood event without putting water through the spillway. Following spillway repairs and determination that the repaired spillway can safely route the spillway**

**design flood as determined by the Dam Safety program, the restriction will be removed.**

The maximum reservoir elevation for winter storage is 5,315 feet with 4,660 acre-feet of storage. This winter maximum helps prevent damage to the riprap and embankment from wind-driven waves and ice. The minimum reservoir elevation for winter storage is 5,275 with 496 acre-feet of storage. This winter minimum helps prevent ice damage to the inlet structure for the outlet works.

### **Safe Drawdown**

Because the stability of Bair Dam has not been thoroughly investigated, DNRC recommends that drawdown rates not exceed one foot per day.

### **Limitations of Appurtenances**

Appurtenances at Bair Reservoir include the spillway and outlet works. At elevation 5,336.4, the maximum capacity of the outlet works' is 650 cfs. The maximum spillway capacity at elevation 5,336.4 feet is 7,880 cfs. Flows greater than 7,000 cfs could overtop the spillway sidewalls. Outlet and spillway rating tables are shown in Appendix A.

### **Dam Operator**

The responsibility for the daily operation of the dam and reservoir rests

with the association and its dam operator. The dam operator is generally authorized to operate the reservoir to meet the association's goal of providing an adequate supply of contracted irrigation water without exceeding safe storage or flow levels. The dam operator's specific responsibilities are to:

1. *Operate the mechanical features of the outlet works*
2. *Coordinate filling of the reservoir and the release of water*
3. *Notify the State Water Projects Bureau (SWPB) of unusual occurrences, such as impending floods or excessive seepage, etc.*
4. *Perform various maintenance tasks*
5. *Monitor weather conditions*
6. *Monitor seepage*

Typically, the out-going dam operator, water users association, and the SWPB train a new dam operator. The dam operator's training focuses on the mechanical operation of the gates, measurement of the storage level, measurement of the rate of water release, and record keeping. The outlet gates are manually operated with a hand crank. The outlet works are intended to be used for controlling the release of irrigation water and not for providing emergency relief.

The dam operator normally is available to observe the dam and perform operating functions daily during the irrigation season. During the non-irrigation season, one of the officers or directors observe and regulate the dam on a monthly basis. Communication among the dam operator, the association,

and the SWPB usually takes place by telephone. Although not routinely available, radio communication may be established during emergencies or unusual occurrences, so the dam operator can speak directly with county authorities and communicate indirectly with the SWPB (see *Bair Dam Emergency Plan*).

### **Weather Monitoring**

The dam operator monitors weather conditions through local weather forecasts and the National Weather Service.

### **Interaction with Other Dams**

With the exception of Fort Peck Dam, the only dams located downstream from Bair Dam are irrigation diversion dams. The safety of these dams is not affected by the operation of Bair Reservoir during either normal or emergency operations. There are no reservoirs of size upstream of Bair Dam. Therefore, interaction with other dams is not a concern during the normal operation of Bair Dam.

If it appears that the dam at Bair will breach, the dam tender should notify the operator at Fort Peck Dam (**406-526-3411**).

## **INSPECTION AND MONITORING**

The SWPB will inspect the dam annually. Appendix B includes an example of a SWPB inspection checklist. In addition to annual inspections, SWPB personnel will inspect the dam and reservoir during and after heavy runoff and severe rainstorms and windstorms, during high storage periods, and after an earthquake. The embankment is not monitored by instrumentation.

### **Structural Features Inspection**

Structural features include the control tower, spillway, and outlet works. (Figure 3) The SWPB will inspect these structures annually as part of its inspection program. Items to be checked or noted include, but are not limited to:

1. *Outlet Works*
  - a) Any differential settlement or movement resulting in cracking of the conduit
  - b) Erosion of the seals or concrete by cavitation immediately downstream of the gates
  - c) Major seepage of water into the conduit
  - d) Major deterioration of exposed concrete due to freeze/thaw cycles or sulfate reactions
  - e) Operation of all gates through a full cycle
  - f) Jet pump, for obstructions and operation

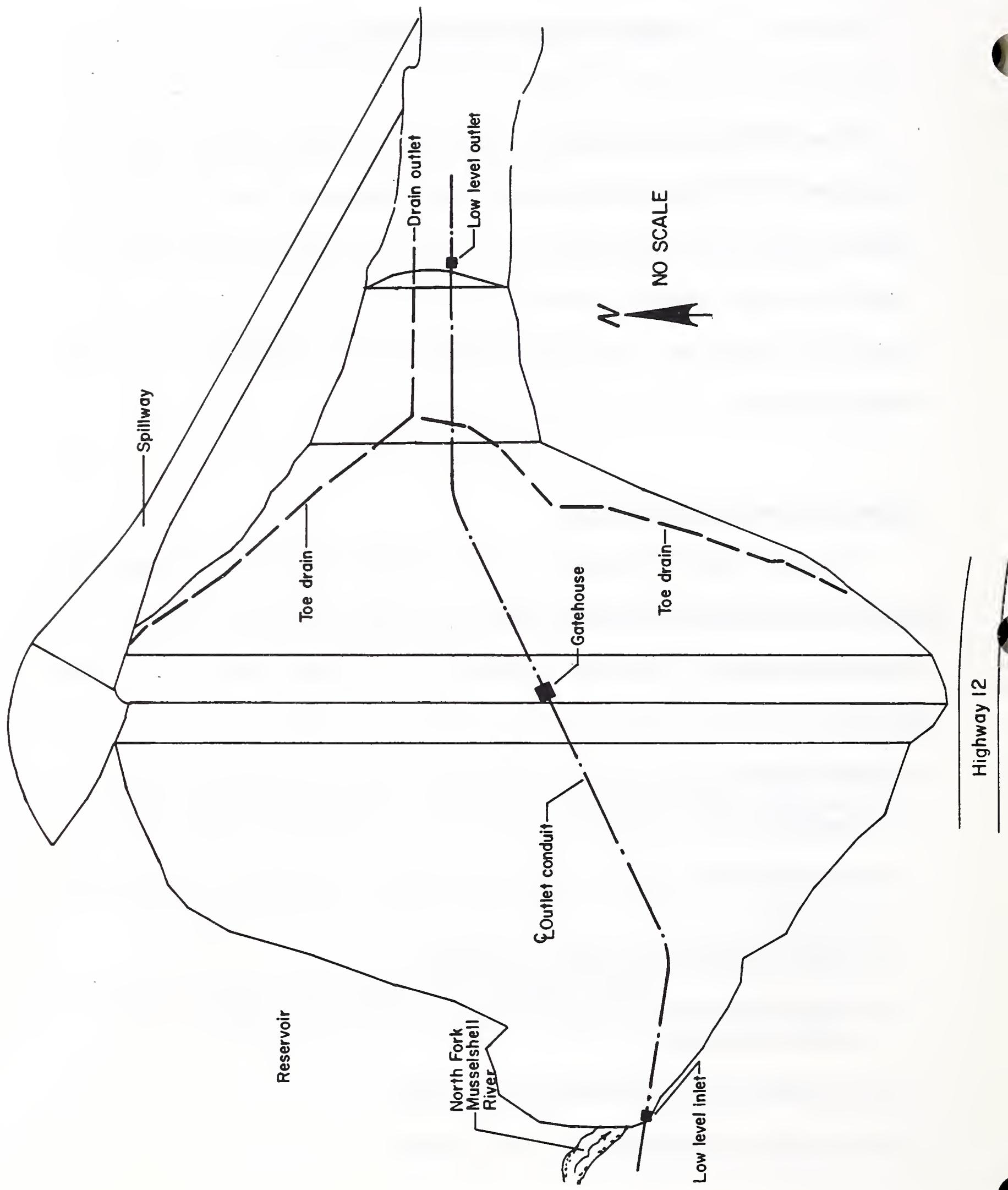


Figure 3. Bair Dam Project

- g) Free, unobstructed operation of the air vent
- h) Corrosion of any metal
- i) Proper lubrication of the gate pedestals

2. *Gatehouse*-- Any damage or vandalism

3. *Spillway*

- a) Deterioration of concrete
- b) Separation or movement of joints
- c) Erosion of the spillway chute, backfill behind the walls, or stilling basin
- d) Blockage of the approach or exit channel

4. *Embankment*

- a) Erosion gullies in the dam.
- b) Damage from burrowing animals or vegetation.
- c) Displacement or loss of rip-rap protection.
- d) Displacement of fill, sink holes, slumps etc.
- e) Any seepage.

### **Riprap Inspection**

The riprap on the upstream face of the dam should be at least 30 inches thick. Immediately after the occurrence of high water, the riprap will be inspected and additional riprap added if needed.

## **Seepage Monitoring**

A foundation drain is contained within the dam. The drain outlet cannot be observed, since the area is covered with several feet of loose rock. However, water does exit from this area into the outlet channel. A V-notch weir was installed in 1997 so the drain discharge can be measured. See discharge table in Appendix A.

There is also a drainage system beneath the concrete spillway, with two outlet locations in the lower portion of the spillway chute.

Seepage has been seen exiting from around the right outlet wing wall at times. This seepage is not measurable.

## **MAINTENANCE**

The association is responsible for the project's routine maintenance.

During regular visits, the dam operator will identify and perform normal maintenance activities. During the annual inspections, the SWPB will also identify items that need maintenance or repair. The association will be required to perform the maintenance items within the time periods specified. The SWPB may supervise major repairs.

### **Routine Maintenance**

As soon as a need is identified, the dam operator will perform any routine maintenance necessary to protect the dam or keep it in good working order. The dam operator will watch for any potential maintenance requirements during normal visits to the dam. Items that may occasionally need attention include, but are not limited to:

1. *Lubrication of gate-operating mechanisms.*
2. *Debris or silt restricting the spillway inlet or the outlet works.* Accumulated debris that could affect the operation of these appurtenances will be removed at once, with all debris removed at least annually.
3. *Erosion gullies on embankment.* Development of erosion gullies will be checked immediately. Gullies will be filled, compacted, and seeded. Particular attention will be paid to the abutment contact areas and the

downstream faces where four-wheel-drive tracks may become a problem.

4. *Rodent damage.* Rodent burrows will be filled immediately and the rodents removed or destroyed.
5. *Upstream slope riprap.* Reservoir riprap normally will be maintained annually, but may occasionally need repairs because of high water or wave action.
6. *Vegetative cover on downstream slopes.* Good vegetative cover will be maintained, but large brush and any trees should be removed.
7. *Noxious weeds.* Noxious weeds on and around the dams should be sprayed at least on an annual basis.
8. *Cleaning spillway and outlet wall tops.* Spillway and outlet wall tops should be clear of any dirt, rocks, grass, brush, and any overhanging vegetation or trees.
9. *Repair of the spillway joints and sealing of cracks in the spillway.*

### **Annual Maintenance**

The SWPB will conduct annual inspections of Bair Dam and Reservoir. During these inspections, any items that require maintenance will be identified and recorded. Items that need annual maintenance include the spillway, outlet works, gates, riprap, roads, and gatehouse. Any other routine items that need immediate attention also will be noted (such as removing trees and brush).

After the association receives the SWPB inspection report, it will develop

a maintenance schedule for identified items. While the dam operator or association members may perform these routine tasks, major repairs are more likely to be performed by a contractor. The SWPB may assist in contracting for repairs and may supervise the repair work.

### **Record Keeping**

The SWPB will maintain records--including photographs--of all inspections and maintenance requirements. These records will also include flow measurements and storage volumes. Anyone who wants to review these records may do so in the SWPB's office at the Department of Natural Resources and Conservation in Helena.

The dam operator will keep records of the reservoir elevation, seepage observations or measurements, and any unusual conditions. These records may be reviewed at the dam operator's house.



## REFERENCES

Berg, Donald, Upper Musselshell Water Users Association President. July 13, 1994 telephone communications with Sterling Sundheim, Regional Office Civil Engineering specialist, Water Resources Division DNRC, Lewistown.

Hoskins-Western-Sonderegger, Inc. March 1981. *Phase 1 Inspection Report, National Dam Safety Program; Missouri-Musselshell Basin, Bair Dam and Reservoir, Meagher County, (MT 6)*. Prepared for the State of Montana (DNRC) under the U.S. Army Corps of Engineers' National Dam Safety Program.



## **APPENDIX A**

### **RATING CURVES AND TABLES**



**Table A-1**  
**BAIR DAM**  
**ACTIVE STORAGE IN ACRE-FEET**

<u>ELEV.</u>	<u>0.0</u>	<u>0.1</u>	<u>0.2</u>	<u>0.3</u>	<u>0.4</u>	<u>0.5</u>	<u>0.6</u>	<u>0.7</u>	<u>0.8</u>	<u>0.9</u>
5,253	0	1	1	2	2	3	3	4	4	4
5,254	5	6	6	7	7	8	9	9	10	10
5,255	11	12	14	15	16	18	19	20	21	23
5,256	24	25	26	28	29	30	31	32	34	35
5,257	36	37	39	40	41	43	44	45	46	48
5,258	49	50	51	53	54	55	56	57	59	60
5,259	61	62	64	65	66	67	69	70	71	73
5,260	74	76	78	80	82	83	85	87	89	91
5,261	93	95	97	99	101	102	104	106	108	110
5,262	112	114	116	117	119	121	123	125	126	128
5,263	130	132	134	136	138	139	141	143	145	147
5,264	149	151	153	155	157	158	160	162	164	166
5,265	168	171	174	176	179	182	185	188	190	193
5,266	196	199	202	204	207	210	213	216	218	221
5,267	224	227	230	232	235	238	241	244	246	249
5,268	252	255	258	260	263	266	269	272	274	277
5,269	280	283	286	288	291	294	297	300	302	305
5,270	308	312	316	319	323	327	331	335	338	342
5,271	346	350	353	357	361	365	368	372	376	379
5,272	383	387	391	394	398	402	406	410	413	417
5,273	421	425	428	432	436	440	443	447	451	454
5,274	458	462	466	469	473	477	481	485	488	492
5,275	496	501	505	510	515	520	524	529	534	538
5,276	543	548	552	557	561	566	571	575	580	584
5,277	589	594	598	603	608	613	617	622	627	631
5,278	636	641	645	650	654	659	664	668	673	677
5,279	682	687	691	696	701	706	710	715	720	724
5,280	729	735	741	746	752	758	764	770	775	781
5,281	787	793	799	804	810	816	822	828	833	839
5,282	845	851	857	862	868	874	880	886	891	897
5,283	903	909	915	920	926	932	938	944	949	955
5,284	961	967	973	978	984	990	996	1,002	1,007	1,013
5,285	1,019	1,026	1,033	1,040	1,047	1,055	1,062	1,069	1,076	1,083
5,286	1,090	1,097	1,104	1,112	1,119	1,126	1,133	1,140	1,148	1,155
5,287	1,162	1,169	1,176	1,183	1,190	1,198	1,205	1,212	1,219	1,226
5,288	1,233	1,240	1,247	1,255	1,262	1,269	1,276	1,283	1,291	1,298
5,289	1,305	1,312	1,319	1,326	1,333	1,341	1,348	1,355	1,362	1,369
5,290	1,376	1,385	1,393	1,402	1,410	1,419	1,428	1,436	1,445	1,453
5,291	1,462	1,471	1,479	1,488	1,496	1,505	1,514	1,522	1,531	1,539
5,292	1,548	1,557	1,565	1,574	1,582	1,591	1,600	1,608	1,617	1,625
5,293	1,634	1,643	1,651	1,660	1,668	1,677	1,686	1,694	1,703	1,711
5,294	1,720	1,729	1,737	1,746	1,754	1,763	1,772	1,780	1,789	1,797
5,295	1,806	1,816	1,827	1,837	1,848	1,858	1,868	1,879	1,889	1,900

**Table A-1 *continued***

<b>ELEV.</b>	<b>0.0</b>	<b>0.1</b>	<b>0.2</b>	<b>0.3</b>	<b>0.4</b>	<b>0.5</b>	<b>0.6</b>	<b>0.7</b>	<b>0.8</b>	<b>0.9</b>
5,296	1,910	1,920	1,931	1,941	1,952	1,962	1,972	1,983	1,993	2,004
5,297	2,014	2,024	2,035	2,045	2,056	2,067	2,077	2,088	2,098	2,109
5,298	2,119	2,129	2,140	2,150	2,161	2,171	2,181	2,192	2,202	2,213
5,299	2,223	2,233	2,244	2,254	2,265	2,275	2,285	2,296	2,306	2,317
5,300	2,327	2,340	2,352	2,365	2,378	2,390	2,403	2,416	2,429	2,441
5,301	2,454	2,467	2,479	2,492	2,505	2,517	2,530	2,543	2,556	2,568
5,302	2,581	2,594	2,606	2,619	2,631	2,644	2,657	2,669	2,682	2,694
5,303	2,707	2,720	2,732	2,745	2,758	2,770	2,783	2,796	2,809	2,821
5,304	2,834	2,847	2,859	2,872	2,885	2,897	2,910	2,923	2,936	2,948
5,305	2,961	2,976	2,992	3,007	3,022	3,038	3,053	3,068	3,083	3,099
5,306	3,114	3,129	3,145	3,160	3,176	3,191	3,206	3,222	3,237	3,253
5,307	3,268	3,283	3,299	3,314	3,329	3,345	3,360	3,375	3,390	3,406
5,308	3,421	3,436	3,452	3,467	3,483	3,498	3,513	3,529	3,544	3,560
5,309	3,575	3,590	3,606	3,621	3,636	3,652	3,667	3,682	3,697	3,713
5,310	3,728	3,746	3,765	3,783	3,802	3,820	3,838	3,857	3,875	3,894
5,311	3,912	3,930	3,949	3,967	3,986	4,004	4,022	4,041	4,059	4,078
5,312	4,096	4,114	4,133	4,151	4,170	4,188	4,206	4,225	4,243	4,262
5,313	4,280	4,298	4,317	4,335	4,354	4,372	4,390	4,409	4,427	4,446
5,314	4,464	4,482	4,501	4,519	4,538	4,556	4,574	4,593	4,611	4,630
5,315	4,648	4,670	4,692	4,713	4,735	4,757	4,779	4,801	4,822	4,844
5,316	4,866	4,888	4,909	4,931	4,953	4,975	4,996	5,018	5,040	5,061
5,317	5,083	5,105	5,127	5,148	5,170	5,192	5,214	5,236	5,257	5,279
5,318	5,301	5,323	5,344	5,366	5,388	5,410	5,431	5,453	5,475	5,496
5,319	5,518	5,540	5,562	5,583	5,605	5,627	5,649	5,671	5,692	5,714
5,320	5,736	5,761	5,787	5,812	5,838	5,863	5,888	5,914	5,939	5,965
5,321	5,990	6,015	6,041	6,066	6,092	6,117	6,142	6,168	6,193	6,219
5,322	6,244	6,269	6,295	6,320	6,345	6,370	6,396	6,421	6,446	6,472
5,323	6,497	6,522	6,548	6,573	6,599	6,624	6,649	6,675	6,700	6,726
5,324	6,751	6,776	6,802	6,827	6,853	6,878	6,903	6,929	6,954	6,980
5,325	7,005	7,034	7,064	7,093	7,122	7,152	7,181	7,210	7,239	7,269
5,326	7,298	7,327	7,356	7,386	7,415	7,444	7,473	7,502	7,532	7,561
5,327	7,590	7,619	7,649	7,678	7,707	7,737	7,766	7,795	7,824	7,854
5,328	7,883	7,912	7,941	7,971	8,000	8,029	8,058	8,087	8,117	8,146
5,329	8,175	8,204	8,234	8,263	8,292	8,322	8,351	8,380	8,409	8,439
5,330	8,468	8,501	8,535	8,568	8,601	8,634	8,668	8,701	8,734	8,767
5,331	8,801	8,834	8,867	8,900	8,934	8,967	9,000	9,033	9,067	9,100
5,332	9,133	9,166	9,200	9,233	9,266	9,300	9,333	9,367	9,400	9,433
5,333	9,467	9,500	9,537	9,574	9,611	9,648	9,685	9,722	9,759	9,796
5,334	9,833	9,867	9,901	9,935	9,969	10,003	10,037	10,071	10,105	10,139
5,335	10,173	10,207	10,242	10,276	10,310	10,344	10,378	10,412	10,446	10,480
5,336	10,514	10,548	10,582	10,616	10,650					

Spillway crest elevation 5,325.0

Minimum dam crest elevation 5,336.4

Dead storage is 24 acre-feet

TABLE A-2

## BAIR DAM LIVE STORAGE TABLE (Pin 1 thru 6)

SLOPE <u>DISTANCE</u>	ELEV. ( <u>Feet</u> )	CONTENTS ( <u>Acre-feet</u> )	SLOPE <u>DISTANCE</u>	ELEV. ( <u>Feet</u> )	CONTENTS ( <u>Acre-feet</u> )
0+00	5332.99		0+59	5312.98	4,276
+05	29.48	8,315	0+60	5312.65	4,216
0+10	5327.44	7,719	+61	12.49	4,186
+11	26.75	7,517	+62	12.39	4,168
+12	25.64	7,192	+63	12.32	4,155
+13	25.44	7,134	+64	12.08	4,111
+14	24.99	7,005	+65	11.92	4,081
+15	24.95	{Concrete Crest 6,992	+66	11.43	3,991
+16	24.59	6,901	+67	11.09	3,929
+17	23.86	6,715	+68	10.84	3,883
+18	23.66	6,665	+69	10.59	3,837
+19	23.59	6,647	0+70	5310.41	3,803
0+20	5323.27	6,566	+71	09.78	3,695
+21	23.00	6,497	+72	09.45	3,644
+22	22.63	6,404	+73	08.77	3,539
+23	22.20	6,295	+74	08.54	3,504
+24	22.07	6,262	+75	08.36	3,476
+25	21.61	6,145	+76	07.91	3,408
+26	21.49	6,114	+77	07.52	3,348
+27	21.35	6,079	+78	07.25	3,306
+28	21.08	6,010	+79	06.90	3,252
+29	20.78	5,934	0+80	5306.54	3,197
0+30	5320.47	5,855	+81	06.38	3,172
+31	20.19	5,784	+82	06.26	3,154
+32	20.00	5,736	+83	06.01	3,116
+33	19.80	5,692	+84	05.81	3,085
+34	19.65	5,659	+85	05.48	3,035
+35	19.50	5,627	+86	05.05	2,969
+36	19.35	5,594	+87	04.71	2,924
+37	19.20	5,562	+88	04.11	2,848
+38	18.98	5,514	+89	03.89	2,820
+39	18.68	5,449	0+90	5303.70	2,796
0+40	5318.17	5,338	+91	03.50	2,770
+41	18.07	5,316	+92	03.44	2,763
+42	17.89	5,277	+93	03.06	2,715
+43	17.70	5,235	+94	02.79	2,681
+44	17.42	5,174	+95	02.16	2,601
+45	16.96	5,075	+96	01.45	2,511
+46	16.78	5,036	+97	01.10	2,467
+47	16.35	4,942	+98	00.66	2,411
+48	16.03	4,873	+99	00.23	2,356
+49	15.74	4,809	1+00	5301.59	2,529 { <sup>Block</sup> #3}
0+50	5316.21	4,912	+01	99.53	2,278
+51	14.88	4,626	+02	99.15	2,239
+52	14.38	4,534	+03	99.00	2,223
+53	14.22	4,504	+04	98.80	2,202
+54	14.09	4,481	+05	98.49	2,170
+55	13.92	4,449	+06	97.89	2,107
+56	13.74	4,416	+07	97.56	2,072
+57	13.65	4,400	+08	97.28	2,043
+58	13.36	4,346	+09	97.01	2,015

TABLE A-2 *continued*

<b>SLOPE DISTANCE</b>	<b>ELEV. (Feet)</b>	<b>CONTENTS (Acre-feet)</b>	<b>SLOPE DISTANCE</b>	<b>ELEV. (Feet)</b>	<b>CONTENTS (Acre-feet)</b>
1+10	5296.53	1,965	1+64	5280.02	730
+11	96.27	1,938	+65	79.97	727
+12	96.02	1,912	+66	79.90	724
+13	95.57	1,865	+67	79.82	720
+14	95.29	1,836	+68	79.73	716
+15	94.97	1,803	+69	79.68	714
+16	94.65	1,776	1+70	5279.60	710
+17	94.32	1,748	+71	79.58	709
+18	94.05	1,724	+72	79.47	704
+19	93.86	1,708	+73	79.38	700
1+20	5293.52	1,679	+74	79.29	696
+21	93.10	1,643	+75	79.19	691
+22	92.82	1,619	+76	79.10	687
+23	92.49	1,590	+77	78.94	680
+24	92.11	1,557	+78	78.81	674
+25	91.60	1,514	+79	78.71	669
+26	91.01	1,463	1+80	5278.64	666
+27	90.72	1,438	+81	78.56	662
+28	90.59	1,427	+82	78.46	657
+29	90.35	1,406	+83	78.34	652
1+30	5290.12	1,386	+84	78.25	648
+31	89.60	1,348	+85	78.18	644
+32	89.14	1,315	+86	78.07	639
+33	88.51	1,269	+87	78.09	640
+34	88.14	1,243	+88	78.08	640
+35	87.84	1,222	+89	77.99	635
+36	87365	1,208	1+90	5277.90	631
+37	87.62	1,206	+91	77.86	629
+38	87.58	1,203	+92	77.70	622
+39	87.40	1,191	+93	77.66	620
1+40	5287.14	1,172	+94	77.59	616
+41	86.91	1,155	+95	77.48	611
+42	86.73	1,142	+96	77.32	604
+43	86.37	1,116	+97	77.20	598
+44	85.92	1,085	+98	77.08	593
+45	85.26	1,038	+99	76.98	589
+46	84.16	970	2+00	5277.06	592
+47	83.92	956	+01	76.75	578
+48	83.69	943	+02	76.57	570
+49	83.41	927	+03	76.42	563
1+50	5283.40	926 { <sup>Block</sup> <sub>#4</sub> }	+04	76.29	557
+51	82.61	880	+05	76.17	551
+52	82.26	860	+06	76.09	547
+53	81.76	831	+07	75.98	542
+54	81.37	808	+08	75.89	537
+55	81.19	798	+09	75.80	533
+56	81.03	789	2+10	5275.70	529
+57	80.88	780	+11	75.62	525
+58	80.71	770	+12	75.52	520
+59	80.53	760	+13	75.46	517
1+60	5280.40	752	+14	75.25	508
+61	80.30	746	+15	75.10	501
+62	80.21	741	+16	74.91	492
+63	80.10	735	+17	74.69	484

TABLE A-2 *continued*

<u>SLOPE DISTANCE</u>	<u>ELEV. (Feet)</u>	<u>CONTENTS (Acre-feet)</u>	<u>SLOPE DISTANCE</u>	<u>ELEV. (Feet)</u>	<u>CONTENTS (Acre-feet)</u>
2+18	5274.58	480	2+69	5264.92	166
+19	74.43	474	2+70	5264.80	164
2+20	5274.25	467	+71	64.64	161
+21	74.15	464	+72	64.48	158
+22	74.05	460	+73	64.31	155
+23	73.95	457	+74	64.15	152
+24	73.87	454	+75	63.99	149
+25	73.72	448	+76	63.91	147
+26	73.56	442	+77	63.82	145
+27	73.40	436	+78	63.74	144
+28	73.24	430	+79	63.65	142
+29	73.05	423	2+80	5263.57	141
2+30	5272.90	417	+81	63.43	138
+31	72.73	410	+82	63.28	135
+32	72.57	404	+83	63.14	133
+33	72.41	398	+84	62.99	131
+34	72.28	394	+85	62.85	128
+35	72.11	387	+86	62.70	125
+36	72.00	383	+87	62.54	122
+37	71.71	373	+88	62.39	119
+38	71.50	365	+89	62.23	116
+39	71.28	357	2+90	5262.08	114
2+40	5271.13	351	+91	62.04	113
+41	70.99	345	+92	62.00	112
+42	70.86	340	+93	61.96	111
+43	70.69	334	+94	61.92	110
+44	70.56	329	+95	61.88	110
+45	70.40	323	+96	61.70	106
+46	70.18	315	+97	61.52	103
+47	70.01	308	+98	61.35	100
+48	69.83	303	+99	61.17	96
+49	69.66	298	3+00	5260.99	93
2+50	69.51	294	{ Top of Pin #6 }	+01	60.84
2+50	68.77	274		+02	60.69
+51	68.61	269	+03	60.55	84
+52	68.45	265	+04	60.40	82
+53	68.29	260	+05	60.25	79
+54	68.13	256	+06	60.12	76
+55	67.97	251	+07	69.99	73
+56	67.76	245	+08	59.87	72
+57	67.55	239	+09	59.74	70
+58	67.35	234	3+10	5259.61	69
+59	67.14	228	+11	59.43	66
2+60	5266.93	222	+12	59.25	64
+61	66.62	213	+13	59.07	62
+62	66.31	205	+14	58.89	60
+63	66.00	196	+15	58.71	58
+64	65.69	187	+16	58.51	55
+65	65.38	179	+17	58.32	53
+66	65.26	175	+18	58.12	51
+67	65.15	172	+19	58.01	49
+68	65.03	169	3+20	5257.91	47

This table was developed from surveys made in 1971, 1973, 1979, 1980 and 1988.

**TABLE A-3**  
**BAIR RESERVOIR - BOAT RAMP**  
**LIVE STORAGE TABLE (Pin 1 thru Pin 4)**

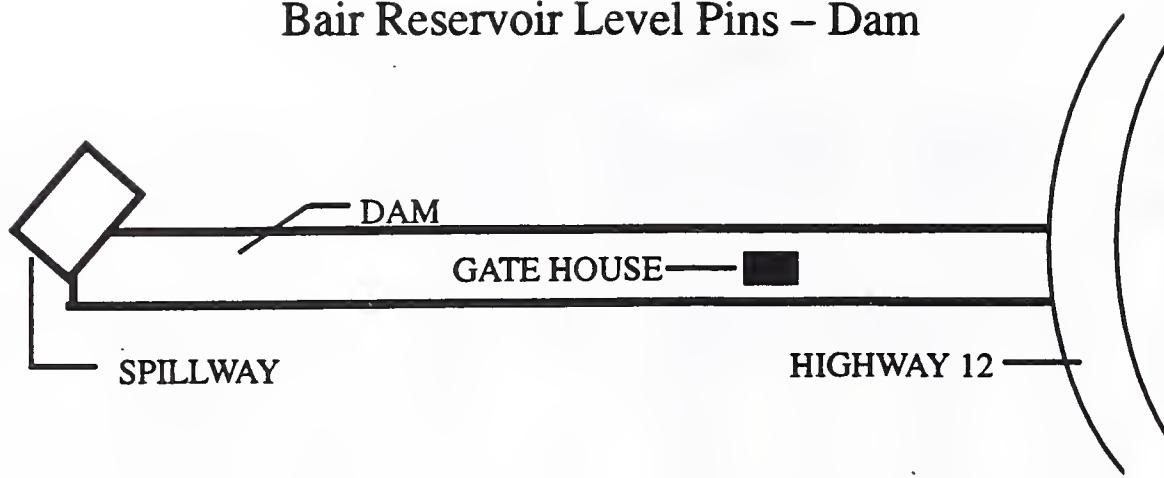
<b>SLOPE DISTANCE</b>	<b>ELEV. (Feet)</b>	<b>CONTENTS (Acre-feet)</b>	<b>SLOPE DISTANCE</b>	<b>ELEV. (Feet)</b>	<b>CONTENTS (Acre-feet)</b>
0+00	5330.46		1+23	5324.14	6,787
+50	26.97	7,582	+24	24.09	6,774
+52	26.98	7,585	+25	23.96	6,741
+54	27.05	7,605	+26	23.86	6,715
+56	26.97	7,582	+27	23.83	6,707
+58	26.89	7,558	+28	23.77	6,692
0+60	5326.88	7,555	+29	23.69	6,672
+62	27.0	7,590	1+30	5323.64	6,659
+64	27.06	7,608	+31	23.53	6,632
+66	27.05	7,605	+32	23.47	6,616
+68	27.00	7,590	+33	23.39	6,596
+70	26.92	7,567	+34	23.31	6,576
+72	26.83	7,541	+35	23.27	6,566
+74	26.73	7,511	+36	23.18	6,543
+76	26.58	7,468	+37	23.06	6,512
+78	26.43	7,424	+38	22.99	6,495
0+80	5326.31	7,389	+39	22.89	6,470
+82	26.13	7,336	1+40	5322.80	6,447
+84	25.91	7,271	+41	22.69	6,419
+86	26.02	7,304	+42	22.66	6,412
+88	26.02	7,304	+43	22.58	6,391
+90	25.78	7,233	+44	22.47	6,363
+92	25.70	7,210	+45	22.40	6,346
+94	25.68	7,204	+46	22.28	6,315
+96	25.63	7,189	+47	22.14	6,280
+98	25.47	7,143	+48	22.04	6,254
1+00	5325.10	7,034	1+50	5321.66	6,158
+01	25.22	7,069	+51	21.61	6,145
+02	25.23	7,072	+52	21.54	6,127
+03	25.16	7,052	+53	21.42	6,097
+04	25.12	7,040	+54	21.29	6,064
+05	25.03	7,014	+55	21.12	6,020
+05.5	25.00	7,005	1+56	20.98	5,985
+06	24.97	6,997	+57	20.84	5,949
+07	24.86	6,969	+58	20.76	5,929
+08	24.84	6,964	+59	20.66	5,904
+09	24.78	6,949	1+60	5320.59	5,886
1+10	5324.74	6,939	+61	20.46	5,853
+11	24.69	6,926	+62	20.24	5,797
+12	24.63	6,911	+63	20.09	5,759
+13	24.59	6,901	+64	19.89	5,712
+14	24.57	6,896	+65	19.72	5,675
+15	24.52	6,883	+66	19.54	5,636
+16	24.49	6,875	+67	19.40	5,605
+17	24.45	6,865	+68	19.24	5,570
+18	24.39	6,850	+69	19.01	5,520
+19	24.34	6,837	1+70	5318.89	5,495
1+20	5324.32	6,832	+71	18.73	5,460
+21	24.31	6,830	+72	18.62	5,436
+22	24.26	6,817	+73	18.48	5,405

TABLE A-3 *continued*

<b>SLOPE DISTANCE</b>	<b>ELEV. (<i>Feet</i>)</b>	<b>CONTENTS (<i>Acre-feet</i>)</b>	<b>SLOPE DISTANCE</b>	<b>ELEV. (<i>Feet</i>)</b>	<b>CONTENTS (<i>Acre-feet</i>)</b>
1+74	5318.20	5,345	2+27	5310.28	3,780
+75	17.96	5,292	+28	10.17	3,759
+76	17.59	5,211	+29	10.08	3,743
+77	17.45	5,181	2+30	5309.96	3,722
+78	17.34	5,157	+31	09.89	3,712
+79	17.22	5,131	+32	09.80	3,698
1+80	5316.99	5,081	+33	09.64	3,673
+81	16.77	5,034	+34	09.53	3,656
+82	16.48	4,970	+35	09.46	3,646
+83	16.31	4,933	+36	09.35	3,629
+84	16.12	4,892	+37	09.25	3,613
+85	15.83	4,829	+38	09.15	3,598
+86	15.66	4,792	+39	09.03	3,580
+87	15.45	4,746	2+40	5308.95	3,567
+88	15.29	4,711	+41	08.89	3,558
+89	15.04	4,657	+42	08.82	3,547
1+90	5314.93	4,635	+43	08.73	3,533
+91	14.79	4,609	+44	08.68	3,525
+92	14.63	4,580	+45	08.63	3,518
+93	14.46	4,549	+46	08.55	3,505
+94	14.31	4,521	+47	08.47	3,493
+95	14.12	4,486			
+96	13.87	4,440			
+97	13.69	4,407			
+98	13.50	4,372			
+99	13.33	4,341			
2+00	5313.19	4,315 { Pin #4			
+01	13.02	4,284			
+02	12.93	4,267			
+03	12.83	4,249			
+04	12.73	4,230			
+05	12.62	4,210			
+06	12.49	4,186			
+07	12.44	4,177			
+08	12.34	4,159			
+09	12.27	4,146			
2+10	5311.98	4,092			
+11	11.86	4,070			
+12	11.80	4,059			
+13	11.70	4,041			
+14	11.61	4,024			
+15	11.48	4,000			
+16	11.40	3,986			
+17	11.29	3,965			
+18	11.18	3,945			
+19	11.09	3,929			
2+20	5310.97	3,906			
+21	10.87	3,888			
+22	10.78	3,872			
+23	10.69	3,855			
+24	10.56	3,831			
+25	10.44	3,809			
+26	10.37	3,796			

This table was developed from 1979 and 1980 surveys.

### Bair Reservoir Level Pins – Dam



0 + 00	#1	STEEL PIN
0 + 50	#2	CEMENT BLOCK WITH RE-BAR
1 + 00	#3	CEMENT BLOCK WITH RE-BAR
1 + 50	#4	CEMENT BLOCK WITH RE-BAR
2 + 00	#5	CEMENT BLOCK WITH RE-BAR
2 + 50	#6	STEEL PIN

SURVEY TO 3 + 20 FT.

### Boat Ramp Pins

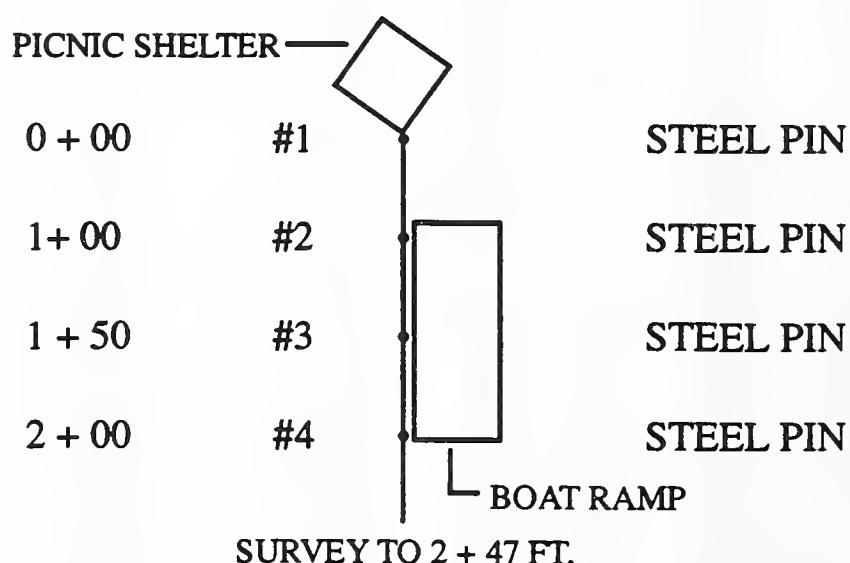


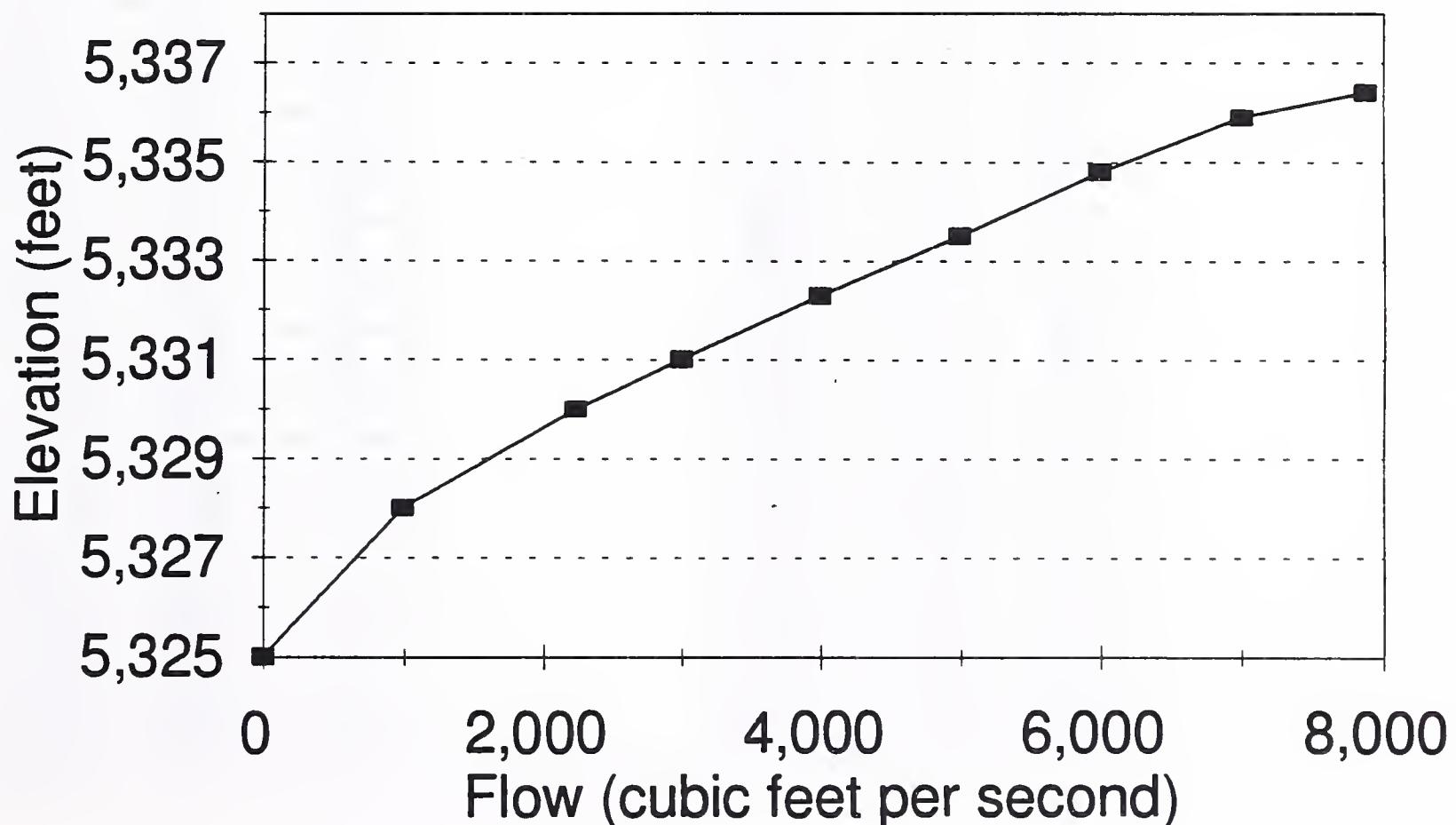
Figure A - 1 Bair Reservoir Elevation Pin Location Map

Table A-4  
BAIR DAM SPILLWAY RATING TABLE

<u>Elevation</u> (feet)	<u>Flow</u> (cfs)
5,325.0	0
5,328.0	1,000
5,330.0	2,240
5,331.0	3,000
5,332.3	4,000
5,333.5	5,000
5,334.8	6,000
5,335.9	7,000
5,336.4	7,880

Figure A-2

## BAIR DAM SPILLWAY RATING CURVE



**Table A-5****V-NOTCH WEIR RATING TABLE**

HEAD (IN)	DISCHARGE		HEAD (IN)	DISCHARGE	
	(GPM)	(CFS)		(GPM)	(CFS)
-----	-----	-----	4.1	77.8	0.173
-----	-----	-----	4.2	82.6	0.184
-----	-----	-----	4.3	87.5	0.195
-----	-----	-----	4.4	92.6	0.206
0.5	0.4	0.001	4.5	98.0	0.218
0.6	0.7	0.001	4.6	103.4	0.230
0.7	1.0	0.002	4.7	109.1	0.243
0.8	1.4	0.003	4.8	115.0	0.256
0.9	1.8	0.004	4.9	121.0	0.270
1.0	2.4	0.005	5.0	127.2	0.283
1.1	3.0	0.007	5.1	133.6	0.298
1.2	3.7	0.008	5.2	140.2	0.312
1.3	4.5	0.010	5.3	147.0	0.328
1.4	5.4	0.012	5.4	154.0	0.343
1.5	6.4	0.014	5.5	161.2	0.359
1.6	7.5	0.017	5.6	168.5	0.375
1.7	8.8	0.020	5.7	176.1	0.392
1.8	10.1	0.022	5.8	183.8	0.410
1.9	11.5	0.026	5.9	191.8	0.427
2.0	13.1	0.029	6.0	199.9	0.445
2.1	14.8	0.033	6.1	208.3	0.464
2.2	16.6	0.037	6.2	216.9	0.483
2.3	18.5	0.041	6.3	225.6	0.503
2.4	20.6	0.046	6.4	234.6	0.523
2.5	22.8	0.051	6.5	243.8	0.543
2.6	25.1	0.056	6.6	253.2	0.564
2.7	27.6	0.061	6.7	262.9	0.586
2.8	30.2	0.067	6.8	272.7	0.608
2.9	32.9	0.073	6.9	282.8	0.630
3.0	35.8	0.080	7.0	293.0	0.653
3.1	38.9	0.087	7.1	303.5	0.676
3.2	42.1	0.094	7.2	314.2	0.700
3.3	45.4	0.101	7.3	325.2	0.725
3.4	48.9	0.109	7.4	336.3	0.749
3.5	52.5	0.117	7.5	347.7	0.775
3.6	56.3	0.126	7.6	359.3	0.801
3.7	60.3	0.134	7.7	371.2	0.827
3.8	64.4	0.144	7.8	383.2	0.854
3.9	68.7	0.153	7.9	395.5	0.881
4.0	73.1	0.163	8.0	408.1	0.909

## **APPENDIX B**

### **INSPECTION CHECKLIST**



**DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION**  
**DAM SAFETY INSPECTION REPORT**

NAME OF DAM \_\_\_\_\_  
DATE INSPECTED \_\_\_\_\_

INVENTORY NO. \_\_\_\_\_ OWNER \_\_\_\_\_  
HAZARD CATEGORY \_\_\_\_\_ OPERATOR \_\_\_\_\_  
TYPE OF DAM \_\_\_\_\_ STREAM \_\_\_\_\_  
YEAR BUILT \_\_\_\_\_ DRAINAGE AREA \_\_\_\_\_

**Reservoir Storage Status**

	Water Surface Elevation (feet)	Storage (acre-feet)
At time of inspection	_____	_____
At spillway crest	_____	_____
At min. dam crest elevation	_____	_____
Flashboard crest elevation	_____	_____

ITEM	YES	NO	REMARKS	*ICC
------	-----	----	---------	------

**1. EMBANKMENT**

A. Crest -- Height= Length= Width=

(1) Any visual settlements?				3
(2) Any misalignments?				4
(3) Any cracking?				1
(4) Any traffic damage?				5
(5) Other?				7

NOTE: \*ICC stands for "Inventory Comment Code" which is found on the Inventory of Montana Dams. This comment code is for use by the Dam Safety Section.

ITEM	YES	NO	REMARKS	*ICC
------	-----	----	---------	------

**1. EMBANKMENT (continued)**

**B. Upstream Face -- Slope=**

(1) Any erosion?				10
(2) Any longitudinal cracks?				9
(3) Any transverse cracks?				9
(4) Is riprap protection adequate?				10
(5) Any stone deterioration?				10
(6) Any visual settlement, sloughing, slumps, depressions or bulges?				9
(7) Adequate grass cover?				14
(8) Debris on the dam face?				15
(9) Other?				16

**C. Downstream Face--Slope=**

(1) Any erosion?				22
(2) Any longitudinal cracks?				19
(3) Any transverse cracks?				10
(4) Any visual settlement, sloughing, slumps, depressions or bulges?				19
(5) Is the toe drain dry?				31
(6) Are the relief wells flowing?				31
(7) Any boils at the toe?				19
(8) Any seepage areas?				17, 18
(9) Any traffic or animal damage?				22
(10) Any burrowing animals?				21
(11) Adequate grass cover?				24
(12) Other?				25

**D. Amount and Type of Vegetation on the Dam**

	14, 24
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ITEM	YES	NO	REMARKS	*ICC
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## 2. ABUTMENT CONTACTS

A) Any erosion?				12, 20
B) Any visual differential movement?				12, 20
C) Any cracks?				12, 20
D) Any seepage present?				36
E) Other?				16, 25

## 3. OUTLET WORKS

### A. Intake Structure -- Size=

(1) Any settlement?				70
(2) Any tilting?				70
(3) Do concrete surfaces show:				
a. Spalling?				70
b. Cracking?				70
c. Erosion?				70
d. Exposed reinforcement?				70
(4) Do joints show:				
a. Displacement or offset?				70
b. Loss of joint material?				70
c. Leakage?				70
(5) Metal appurtenances:				
a. Any corrosion present?				70
b. Any breakage present?				71
(6) Trash rack?				71
a. Condition?				71
b. Anchor system secure?				71
(7) Other?				71

ITEM	YES	NO	REMARKS	*ICC
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### 3. OUTLET WORKS (continued)

B. Conduit -- Type = Size =

(1) Do concrete surfaces show:				
a. Spalling?				76
b. Cracking?				76
c. Erosion?				76
d. Exposed reinforcement?				76
(2) Do joints show:				
a. Displacement or offset?				76
b. Loss of joint material?				76
c. Leakage?				76
(3) Is the conduit metal?				76
a. Any corrosion present?				76
b. Protective coatings adequate?				76
(4) Is the conduit misaligned?				76
(5) Any calcium deposits?				76
(6) Other?				76

### C. Gates and Tower

(1) Gates:				73, 74
a. Size: Operating:	Emergency:			
b. Type: Operating:	Emergency:			
(2) Controls operational?				75
(3) Controls lubricated?				75
(4) Operational problems?				75
(5) Leakage around gates?				73, 74
(6) Condition of gate seals?				73, 74
(7) Any cavitation damage? If so, describe?				73, 74
(8) Describe air vent-size and condition.				73, 74

ITEM	YES	NO	REMARKS	*ICC
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### 3. OUTLET WORKS (continued)

#### C. Gates and Tower (continued)

(9) Is there a jet pump?				82
a. Is it operational?				82
b. Leakage?				62
(10) Is the tower dry? _____ wet?				77
(11) Any seepage in the tower?				77
(12) Condition of the tower?				77
(13) Any safety problems?				77
(14) Ladder in good condition?				77
(15) Condition of the gate house?				81
(16) Emergency plan completed for the dam?				43
a. Posted in the gatehouse?				43
(17) Other?				82

#### D. Stilling Basin

(1) Do concrete surfaces show:				
a. Spalling?				62
b. Cracking?				62
c. Erosion?				62
d. Exposed reinforcement?				62
(2) Do joints show:				
a. Displacement or offset?				62
b. Loss of joint material?				62
c. Leakage?				62
(3) Do energy dissipators show:				
a. Signs of deterioration?				62
b. Are they covered with debris?				62
(4) Other?				63

ITEM	YES	NO	REMARKS	*ICC
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### 3. OUTLET WORKS (continued)

#### E. Downstream Channel

(1) Is the channel:				
a. Eroding or backcutting?				38
b. Sloughing?				38
c. Obstructed?				40
(2) Is released water:				
a. Undercutting the outlet?				52, 62
b. Eroding the embankment?				52, 62
(3) Other?				56, 63

### 4. SPILLWAY

#### A. Description

(1) Location?				N/A
(2) Type of Spillway?				N/A
(3) Size of Spillway?				N/A
(4) Spillway lining?				N/A
(5) Is there a weir?				61
(6) Is the spillway in good condition?				N/A
(7) Any drains?				N/A
a. Describe the condition of drains.				64

#### B. Does spillway show:

(1) Any cracking concrete?				57, 58
(2) Any spalling concrete?				57, 58
(3) Any exposed reinforcement in the concrete?				57, 58
(4) Any erosion?				52

ITEM	YES	NO	REMARKS	*ICC
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**4. SPILLWAY (continued)**

**4. B. Does spillway show: (continued)**

(5) Any slope sloughing?				51
(6) Any obstructions?				51
(7) Displacement or offset joints?				59
(8) Loss of joint material?				57, 58
(9) Leakage at the joints?				57, 58
(10) Other?				63

**C. Do the energy dissipators show:**

(1) Signs of deterioration?				62
(2) Any cracking?				62
(3) Any spalling?				52
(4) Any exposed reinforcement?				52
(5) Are they covered with debris?				62
(6) Other?				64

**D. Has release water:**

(1) Eroded the embankment?				52
(2) Undercut the outlet?				52
(3) Eroded the downstream channel?				52
(4) Other?				56

**E. Emergency Spillway**

(1) Is there an emergency spillway?		(If YES, describe)	55

ITEM	YES	NO	REMARKS	*ICC
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## 5. RESERVOIR CONTROL

A) Recent upstream development?				47
B) Recent downstream development?				42
C) Slides in reservoir area?				44
D) Change in reservoir operation?				48
E) Large impoundment upstream?				48
F) Any debris in the reservoir?				50
G) Other?				50

## 6. INSTRUMENTATION

A) List type(s) of instrumentation:				27-33
B) In good condition?				27-33
C) Read periodically?				27-33
D) Is data available?				27-33
E) Include all data gathered since last report.				

## 7. DOWNSTREAM CONDITION

### A. Downstream Land Use.

	41
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This dam was inspected by:

Additional comments and recommendations. (Use additional pages)



